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(54) PNEUMATIC BURROWING APPARATUS

(71) I, PAUL SCHMIDT, a German citizen, of 5945 Saalhausen, Winterbergerstrasse 70, Germany, trading as TRACTO-TECHNIK PAUL SCHMIDT, a German firm of 5940 Lennestadt/Saalhausen, Germany, do hereby declare the invention, for which I pray that a patent may be granted to me and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a self-propelled, pneumatically-operated burrowing apparatus for driving or enlarging holes or channels in earth, the apparatus comprising a tubular housing; a percussion piston which reciprocates in the housing; and a striker tip arranged to slide in an axial direction relative to the housing and to which kinetic energy is imparted by the percussion piston in a working direction axial of the housing.

Apparatus of this kind serves primarily for laying supply mains such as, for example, water mains, and electric or telephone cables below streets or pavements without having to tear up the road surface or the pavement at the time.

In known burrowing apparatus, the housing of the apparatus is subjected to very high loading, so that its working life normally amounts only to a maximum of 500 hours. Furthermore, the diameter of the housing is up to 135 mm or more, although in practice 50 mm may be adequate for the diameter of the bore which is to be made. The large diameter of the housing gives rise to high friction, which greatly reduces the rate of advancing of the tool. Furthermore, the danger of damage to the road surface by transverse waves is increased, as the already well-compacted subsoil under the road is forced upwards against the road surface by the advancing of the burrowing apparatus, causing the road surface to lift.

Further disadvantages of conventional types of pneumatic burrowing apparatus are high air consumption due to the large pressure surfaces involved, the risk of deviation from the required line of bore because of the large diameter of the housing, as well as the high production costs which result from the interior of the large diameter housing being machined from said solid material.

The object of the invention is to produce an improved burrowing apparatus.

In accordance with the invention, there is provided a self-propelled pneumatically-operated burrowing apparatus for driving or enlarging holes or channels in earth, the apparatus comprising a tubular housing, a percussion piston which is reciprocable in the housing; and a striker tip arranged to slide in an axial direction relative to the housing and to which kinetic energy can be imparted by the percussion piston in a working direction axial of the housing; in which apparatus the striker tip on impact by the percussion piston thrusts the housing forward in the working direction by acting against adjustably pre-stressed resilient means contained in the housing, and in which the travel of the striker tip relative to the housing is limited by front and back stops.

The apparatus of the present invention has been shown to be advantageous in that not only is a smaller impact energy necessary than in the case of comparable conventional burrowing apparatus, but also the loading on the housing is smaller.

This is to be attributed to the fact that the striker tip is not fixed to the housing but is slidably mounted relative to the housing and acts on the housing through the resilient means. Hence, the impact applied to the striker tip acts primarily on the striker tip and only to a much smaller extent on the housing. The main part of the energy is therefore effective at the working edge of the striker tip to break up the soil

and rock, whereas only a relatively small amount of the impact energy acts on the housing, after a time delay due to the resilient means, to propel the apparatus forwards through the hole. This results in that the striker tip, after impact by the percussion piston, moves at a much higher speed, and the housing moves at a much lower speed, than in the case of conventional burrowing apparatus. With the improved advancing which is obtainable, the same amount of useful energy for breaking up the rock etc. can be applied to the tip using a smaller percussion piston surface acted upon by the compressed air, and the housing diameter can be considerably reduced. In consequence of this there is also a significant reduction of the frictional resistance in the ground. Furthermore, the housing wall can be thinner because only part of the energy is applied thereto. This results in an appreciable reduction in the production costs.

Embodiments of the invention will now be described, by way of example, with reference to the acompanying drawings, in which:

Figure 1 is a partly-sectioned side view of a burrowing apparatus in accordance with the invention;

Figure 2 is a longitudinal sectional view of an alternative form of burrowing apparatus in accordance with the invention;

Figures 3 to 5 are longitudinal sectional views of a third burrowing apparatus in accordance with the invention, showing, respectively, different operating positions of the parts of the apparatus,

Figure 6 is a broken sectional view of a detail of the apparatus of Figures 3 - 5, on an enlarged scale,

Figure 7 is a pictorial view of a mounting for inserting the burrowing apparatus of Figures 1 to 6 in the ground;

Figure 8 is a sectional view of part of a burrowing apparatus in accordance with the invention for reboring an existing bore in the earth;

Figure 9 is a side view of a direction-finder frame for aligning the burrowing apparatus;

Figure 10 is schematic side view of a burrowing apparatus for boring a second hole parallel to an existing hole, and

Figures 11 and 12 show steering devices for a burrowing apparatus.

Referring to Figure 1, a housing of a burrowing apparatus in accordance with the invention includes a tubular body 1 comprising a commercial hydraulic tube, which is polished and chromium-plated for protection against corrosion and to reduce friction, has an outer diameter of 65 to 95 mm, and is provided at both ends with an internal thread. Into one end of the tubular body 1 a bush 2 is screwed. The bush has, at the centre of its length, a collar 3 of the same outer diameter as the body 1 and has a reduced-diameter threaded portion extending from the collar 3 to the end remote from the body 1. The collar 3 is provided with holes 4 round its periphery to accomodate a hook spanner for screwing the bush into the body 1.

On the threaded portion of the bush 2 remote from the body 1 is screwed a housing head 5 which has the same outer diameter as the collar 3 and the housing tube 1. The end wall of the housing head 5 remote from the bush 2 has an axial aperture through which extends a shank 7 of a conical striker tip 8. The major diameter of the striker tip is the same as the outer diameter of the tubular body 1 and of the collar 3 of the bush 2. The striker tip 8 has a collar 10 which encircles a collar 6 formed on the end wall housing head 5.

On to the free end of the shank 7 is screwed a collar 11 by which the shank 7 is guided in the housing head 5. The collar 11 has holes 12 in its end face to receive a spanner for screwing the collar on to the shank 7. Between the inner surface of the end wall of the housing head 5 and the collar 11 on the shank 7 is resilient means comprising a compression spring 13, which is positioned on the shank 7 and is adjustably prestressed by the collar 11. The adjustable pre-stressing of the spring 13 ensures that the striker tip 8, in the starting position as shown, lies with its end face adjacent the collar 6 of the housing head 5, but direct end contact is prevented by a resilient washer 14 arranged between the striker tip 8 and the housing head. All the screwed parts are secured against coming undone by locking plates.

In operation, a blow is struck by a pneumatically-operated percussion piston 16 against the shank 7 of the striker tip 8 via an intermediate piston 15 which, in the starting position as shown, lies against the shank 7 of the striker tip 8, so that the striker tip 8 shoots forward in the working direction relative to the housing head and penetrates the ground. The intermediate piston 15 contributes to the operation in that, for example, stones which cannot be displaced are shattered by the striker tip vibrating ahead of the housing. The piston 15 is for that purpose arranged slidably in the axial direction in the bush 2, and is supported in the bush 2 by a collar 17 against annular resilient buffers 18 encircling reduced-diameter portions of the piston 15 in front of and behind the collar 17. When the striker tip 8 shoots forward, the housing 1 follows this movement under the pressure of the spring 13 and the resilient buffers 18. The buffers 18 are retained in the bush 2 by an end wall 19 of the bush

2 and a washer 20 which is secured in the bush 2 by a circlip 30. The intermediate piston 15 forms a unit with the bush 2 and the resilient buffers 18, as does the housing head 5 with the striker tip 8, the collar 11 and the spring 13. In general, for the resilient means formed by the spring 13, it is a question of amount of its compression in the furthest forward position of the striker tip in the housing in the working direction being insufficient to cause the spring turns to be completely closed up, i.e. the spring to become "coil bound".

The percussion piston 16 is guided in the housing 1 by means of two axially-spaced guide rings 32 and 33 formed on the periphery of the piston. Slide rings 34 are provided in annular grooves in the guide rings 32 and 33 to reduce the friction against the housing 1. The guiding of the percussion piston 16 by the rings 32 and 33 ensures adequate freedom of movement of the percussion piston 16, even in the case of relatively large distortion of the housing body 1. Furthermore, the percussion piston 16 has a bored-out end remote from the striker tip, and this end seals against a control sleeve 35 which is retained by a collar 36 in a recess in the inner bore of the tubular body 1 by a sleeve 37 screwed into the associated end of the body. The sleeve 35 extends through the sleeve 37 which projects from the body 1 and is slightly larger in diameter than the body.

The control sleeve 35 has, at its end facing away from the percussion piston 16, a connection 38 for a compressed air supply which is fed by a hose from a compressor (not shown). In operation, the compressed air from the compressor enters the bored-out end of the percussion piston 16 through an inner bore 39 in the control sleeve 35, so that the percussion piston is accelerated in the direction of the striker tip 8. The percussion piston 16 is thereby moved in the housing 1 towards the intermediate piston 15. The air in the body 1 in front of the percussion piston 16 in the working direction escapes along the surface of the percussion piston wall. For this purpose the percussion piston 16 is provided with a longitudinal recess extending between the guide rings 32 and 33 along the external surface of the wall 31, which recess is connected with a longitudinal groove 40 in the guide ring 33, which groove extends through the end face of the piston 16 at the leading end in the working direction, and therefore communicates with the interior of the housing between the percussion piston 16 and the intermediate piston 15. The recess between the guide rings 32 and 33 is also connected, by an aperture 41 formed through the percussion piston wall 31, with a recess 42 in the periphery of the control sleeve 35, the recess 42 being vented to the outside atmosphere.

However, after about half the travel towards the intermediate piston has been covered, the connection between the recess 42 and th recess in th wall 31 is interrupted; this being achieved by appropriate dimensioning and positioning of the recess 42 and the bore 41. The interior of the housing lying in front of the percussion piston 16 in the working direction is thereby closed off, i.e. it is no longer vented. Consequently, as the percussion piston moves further towards the intermediate piston due to the pressure of the compressed air supplied to the bored-out end, air pressure builds up in the interior of the housing in front of the percussion piston 16. This air pressure, after the impact of the percussion piston 16 on the intermediate piston 15 and the release of the kinetic energy of the percussion piston effecting the forward drive of the striker tip 8 and the housing 15, accelerates the piston 16 in the reverse direction.

Simultaneously with the impact of the percussion piston 16 on the intermediate piston 15, a connection is formed, by use of a suitable length of the control sleeve 35, through the bore 41 in the wall 31 of the percussion piston 16, from the interior of the housing between the percussion piston 16 and the intermediate piston 15 to the inner bore 39 of the control sleeve 35, and the percussion piston experiences, in opposition to the action of the compressed air fed to the bored-out end, air pressure acting on the other end. Since the area at the other (forward) end is larger than the area subjected to pressure at the back end, the percussion piston 16 moves back to its starting position under the difference of pressure on the two areas.

Before the starting position is reached in which the percussion piston 16 rests against the collar 36 on the control sleeve 35, a connection is again formed, from the interior of the part of the housing body 1 lying between the percussion piston 16 and the intermediate piston 15, to the recess 42 in the control sleeve 35 which is vented to the atmosphere so that the air pressure in this interior drops and the percussion piston 16 is braked by the pressure of the compressed air feed, which by this time is acting only on the bored-out end of the percussion piston. After reaching the starting position in which the action of the compressed air is maintained in the bored-out end of the piston 16 and the interior of the housing in front of the forward end is vented, the piston 16 is set in motion for another blow on the intermediate piston 15.

The venting of the interior of the tubular body 1 via the recess 42 in the control sleeve 35 takes place because there are bores 43 running axially through the collar 36 of the control sleeve 35. Furthermore, the rear end of the body 1, into which the bores 43 open, is either open or is provided with a protective tube 44 of synthetic material through which air can escape from the housing body 1, even when the housing is completely underground, and which protectively encloses the compressed air main leading to the housing 1. The protective tube 44 is attached to the housing 1 by a compression union. In detail, the parts of the compression union are a ring 45 having a conical outer surface which expands the tube 44 at its end which is to be attached to the housing, a cutter ring 46 which encircles the protective tube 44, and a clamping nut which screws on to the sleeve 37 and forces the cutter ring 46 against a chamfer on the inside of the sleeve 37 so that the forward edge of the cutter ring is compressed and digs into the outer wall of the protective tube, the tube thereby being securely held in the sleeve 37. Optionally, instead of the cutter ring 46 a simple conical clamp ring having axial slots might be provided. The clamp ring then clamps tightly round the protective tube 44 when the nut 47 is tightened, the slots allowing the clamp ring to compress.

The striker tip and part of the housing of an alternative burrowing apparatus in accordance with the invention are shown in Figure 2. The housing comprises a housing head 61 screwed directly into a housing body 60. The housing head encircles a striker tip 62 which is formed at the forward end as a cylindrical gouge having a spherical recess in its working tip. At its other end the striker tip 67 has a piston 66 and a shank 63. The shank 63 forms the impact surface for an associated percussion piston (not shown). In the starting position as shown, the shank lies in the inner bore of a ring 64 which is held against a shoulder in the housing body 60 by the housing head 61. The movement of the striker tip 62 is guided by the working end sliding in an aperture at the front end of the housing head 61 and by the piston 66 sliding in a bore at the rear end of the housing head 61. The ring 64 limits the movement of the piston 66 in the direction opposite to the working direction of the striker tip 62, whilst movement in the working direction is limited by a shoulder 65 in the bore in the housing head 61.

In the forward movement, the striker tip 62 bears against the housing head 61 via the piston 66 and cup springs 67 which, after each blow, move the striker tip from its furthest forward position in the housing head back to its starting position.

Whilst in the embodiment shown in Figure 1, the intermediate piston 15 ensures by its resilient buffers 18 that the striker tip 8, in spite of its small mass relative to the mass of the percussion piston 16, does not make too great a movement for the spring 13, (i.e. prevents excessive compression of the spring 13), excessive compression of the cup springs 67 in the embodiment shown in Figure 2 is prevented by the shoulder 65.

In the event of an impact by the percussion piston on the shank 63 of the striker tip 62, the latter is driven forward, like the striker tip 8 in Fig. 1, to protrude further from the housing head 61. A pressure is exerted, via the cup springs 67, on the housing head 61, and therefore on the housing tube 60, in the working direction of the striker tip 62. With adequate strength in the cup springs 67, this pressure is so strong that the housing comprising the tube 60 and the housing head 61 follows the striker tip 62, just as the housing in Fig. 1 follows the striker tip 8 under the pressure of the spring 13 and the resilient buffers 18. On the other hand, the friction opposing movement of the housing in the ground and the movement of the housing in the direction opposite to the working direction of the striker tip 62 resulting, if the occasion arises, from a preceding return of the percussion piston into its starting position, is only overcome by the impact of the pistons 66 on the shoulder 65 on the housing head. In any case there occurs, as in Fig. 1, in the form of a vibratory movement, advancing of the striker tip 62 in relation to the housing head 61 and the housing tube 60. This improves the advancing relative to that obtained with conventional burrowing apparatus.

Moreover, the rate of advancing of the apparatus in Fig. 2 is increased further by a ring 68 placed on the housing head 61; the ring having a larger outer diameter than the housing tube 60 and the housing head 61. The outside of the ring 68 tapers in the same direction as the housing head 61, i.e. in the working direction of the striker tip 62, and the ring displaces the ground in such a way that the hole formed in the ground has a larger diameter than the housing. This considerably reduces the friction of the housing in the hole.

If the apparatus has to be retrieved backwards out of the bore, for example for realignment in the event of the bore running in an undesirable direction, the travel of the apparatus is reversed by reverse con-

trol of the associated percussion piston. In order that the ring 68 should not prevent this backwards movement of the apparatus, the fit of the ring 68 on the housing head 61 is so selected that the ring frees itself from the housing head 61 if the ring 68 becomes jammed in the bore when the housing is moved backwards.

A further increase in the rate of advancing of the apparatus in the bore is effected by profile gooves which run transverse to the length of the housing and largely prevent backward movement of the housing on the return stroke of the percussion piston. A saw-tooth profile with teeth 70 pointing backwards relative to the striker tip, as shown in Fig. 2, has proved particularly advantageous.

The reverse control of the percussion piston for backwards movement of the apparatus is effected, in the case of a further burrowing apparatus in accordance with the invention, as shown in Figs. 3 to 6, by means of a drag-rope 69. The percussion piston 145 is, in this case, formed with an axial bore 146 at its rear end, in which bore fits a piston 147 on the forward end of a tubular control member 135, to the free end of which compressed air is fed. The member 135 is slidably supported in a bore in a sleeve 138 which has at its forward end a flange 137 by which it is clamped in the tubular housing of the apparatus. The flange 137 has a number of passages 101 therethrough to allow air to escape from the housing.

At two spaced-apart positions along the sleeve 138 are a number of radial bores round its circumference for receiving balls 139. In the operating position of the control member 135 shown in Figs. 5 and 6, the balls 139 are located in two annular grooves 140 and 141 in the control member for return motion. In the operating position shown in Figs. 3 and 4 for forward motion, the balls 139 are located in the groove 141 and in a further annular groove 142 in the control member 135, spaced from the groove 141 by the same distance as is the groove 140. By the location of the balls 139 in the groove 141 and the groove 140 or 142, the control sleeve 135 is locked in the respective operating position. The balls 139 are held in the respective locking position by a sleeve 143 which is mounted slidably in the housing of the apparatus and is urged towards the front of the housing by a spring 148. The sleeve 143 in that position holds the balls down into the annular grooves. When the drag-rope 69 which is attached to the sleeve 143 is operated for switching-over from reverse to forward motion, the sleeve 143 slides rearwardly from the locking position as shown in Fig. 6 to a position in which recesses 144 in the sleeve 143 lie over the balls 139. The balls are therefore freed to the extent that they can move radially out of the annular grooves 140 and 141 when a spring 136 forces the control member 135 forward into the operating position for forward motion on interruption of the compressed air feed to the apparatus. Locking of the control member 135 in this operating position is effected automatically on releasing the drag-rope 69, which allows the sleeve 143 to return to its original position so that it forces the balls 139 into the grooves 141 and 142 of the control member 135.

Switching over of the burrowing apparatus from forward to reverse motion necessitates another actuation of the drag rope 69 whilst maintaining the compressed air feed. Then, with a suitable design of the spring 136, the control member 135 moves back under the compressed air pressure, against the spring pressure, into the original position shown in Fig. 6.

The changeover of the control member 135 from the operating position for forward motion to the operating position for return motion has the effect of moving the piston 147 so that its position relative to apertures 149 in the percussion piston is changed. The result is that the time interval for which the space lying in front of the percussion piston 145 in the working direction is vented via the apertures 149 is shortened for an unchanged stroke time of the percussion piston, whereas the time interval for which the action of the compressed air on the forward end of the percussion piston in the direction opposite to the working direction is correspondingly lengthened. Consequently, the movement of the percussion piston towards the striker tip is braked early and, if necessary, impact of the percussion piston on the striker tip can be completely prevented. The movement of the percussion piston in the reverse direction is less braked so that the percussion piston strikes against the flange 137 and imparts a backwards motion to the housing.

A protective tube (not shown) can be attached to the end of the housing of the burrowing apparatus. For this purpose, the ring 150 by which the sleeve 138 is held in the housing can be provided with a threaded extension at its rearward end, with a number of grooves running in the axial direction across the screw thread. The grooves give the extension the effect of a thread-forming tap, so that the protective tube can, without pre-threading, be screwed on to the extension which thereby cuts a screw thread into the protective tube. Alternatively, a clamp might be used for attaching the protective tube to

the housing. The protective tube can be provided with an opening to be used for drainage when it is in the ground.

A striker tip 109 is shown in Figs. 3 to 5, which, similarly to the striker tip in Fig. 2, is formed as a gouge and is supported slidably in the housing. The striker tip 109 has a displacement cap 110 with an annular collar 111 which locates over a spigot on the forward end of the housing. The displacement cap 110 has a tapered bore which mates with a tapered intermediate portion of the striker tip 109 so that the cap is, without any additional auxiliary means, firmly held on the striker tip. As the smaller diameter of the taper is towards the forward end of the striker tip 109, the cap can be readily detached in the working direction.

In Fig. 7 a mounting platform 75 is shown, by means of which a burrowing apparatus in accordance with the invention may be introduced into the ground from a required position and at a required inclination at the start of a boring operation. The mounting platform 75 has two clamps 76 and 77 shaped to fit the contour of the housing of the burrowing apparatus, which clamps receive the housing between them and position the housing parallel with the long axis of the platform. The clamps 76 and 77 are pivotally mounted parallel to each other on parallel levers 78 and 79 which are pivoted at their ends to the platform 75. When the levers 78 and 79 are in a position at right angles to the upper surface of the platform, the separation of the clamps is greater than the housing diameter. Because of the geometry of the parallel levers 78 and 79, the clamps 76 and 77 close towards one another when the levers 78 and 79 are moved away from this position. Conversely, the clamps 76 and 77 open when the parallel levers 78 and 79 are moved from an inclined position into the above-mentioned position. The clamps 76 and 77 are urged to close by a tension spring 80 attached at one end to the lever 79 and at the other end to the platform 75. For insertion of the housing of the burrowing apparatus between the clamps, the parallel levers can be swung by hand against the force of the tension spring 80 by taking advantage of the length of the lever 79. After insertion of the housing, the lever 79 is released and the clamps 76 and 77 close automatically round the housing. Using the direction of pull of the tension spring 80 and the direction of insertion of the housing shown in Fig. 7, the clamp 76 closes towards the clamp 77 by movement of the clamps and of the levers 78 and 79 in the opposite direction to the working direction of the striker tip.

On starting up the burrowing apparatus by feeding compressed air to it, the percussion piston reciprocates in the housing and forces act on the housing in both directions axial to the housing. Because of the clamping of the housing between the clamps 76 and 77, and the swingable arrangement of these clamps, the force acting on the housing in the working direction of the striker tip leads to a swinging motion of the clamps 76 and 77 against the force of the tension spring 80. The clamps 76 and 77 therefore open momentarily, and the housing slides forward between them with the energy imparted to it. On the other hand, the force of the return stroke acting on the housing in the other axial direction, i.e. in the direction of pull of the tension spring 80, leads to an increased grip between the clamps, which prevents backward movement of the housing. Hence, the clamps 76 and 77 with the parallel levers 78 and 79 form a backstop which, with adequate fixing of the platform 75 relative to the ground, ensures that the burrowing apparatus penetrates the ground.

For fixing the platform 75 to the ground, the platform is connected with a baseplate 88 which is anchored in the ground by ground-spikes 81 before alignment of the platform. Alignment of the platform 75 is effected by swinging it about horizontal and vertical axes. For that purpose, the platform 75 is connected with the baseplate 88 via a universal joint, which is formed by a turntable 89 arranged to be able to rotate on the baseplate 88, the turntable having eyes 90 for journalling the platform 75 to allow it to pivot. After alignment by swinging the turntable about the vertical axis, the turntable can be easily locked by a locking screw 91 in the desired orientation. After pivoting the platform 75 about the eyes 90, i.e. about the horizontal axis, locking is effected by bolts 92 formed as wing bolts, which in addition enable exceptionally precise setting about the horizontal axis. As shown in Fig. 7, two wing bolts 92, arranged on opposite sides of the horizontal pivot, are provided to clamp the platform 75 by pressure against the baseplate 88.

The actual alignment is facilitated by a level, such as a spirit-level, and a sighting device 82. The device 82 comprises a post 83 which is fixed to the platform 75 perpendicular to the longitudinal axis of the platform and carries at its upper end, on a crossbar 84, a rear sight 85 and a front sight 86 with a line of sight parallel with the long axis of the platform for sighting on a reference point.

The housing of the burrowing apparatus when mounted on the platform 75 is supported between the clamps 76 and 77 and

is supported by a dished support 87 spaced from the clamps 76 and 77. The support 87 not only improves the parallel position of the housing between the clamps 76 and 77, since it reduces the bending load on the clamp 76 to a negligibly small amount, but also facilitates the introduction of the housing between the clamps 76 and 77 and the application of a protective tube enclosing the compressed air feed to the housing, and in certain cases the drag-rope.

Fig. 8 shows part of a burrowing apparatus as in Figs. 3 to 5 modified for enlarging an already-existing bore in the earth. In Fig. 8, instead of the displacement cap 110 of Figs. 3 to 5, a displacement cap 120 is arranged on the striker tip 109, and the housing of the burrowing apparatus is surrounded by a supplementary sleeve 121. The displacement cap has at its forward end a cylindrical portion with a diameter equal to or very slightly smaller than the already existing bore in the earth, which ensures troublefree guidance of the ram-borer apparatus in the already-existing bore. The rearward end of the displacement cap 120 is tapered and has a major diameter equal to that of the sleeve 121 to determine the diameter of the bore produced in the earth.

Even for boring out an already existing bore in the earth, exact alignment of the burrowing apparatus is important. However, with the employment of a level, difficulties arise if the ram-borer apparatus must be laid at a predetermined inclination. Such inclination can easily be set by a direction finder 122 as shown in Fig. 9. The direction finder has a sighting arrangement consisting, for example, of back and front sights for sighting on a predetermined target point, and a plumb bob 123. For alignment, the direction finder is mounted on the housing of the ram-borer apparatus, indicated in broken line in Fig. 9, by feet 124 which are shaped to fit on the housing. By means of the plumb bob 123 and a scale (not shown) with which the bob cooperates, any alignment of the burrowing apparatus can easily be determined.

This is also possible if a burrowing apparatus 126 is connected, as shown in Fig. 10, to a guide body 125 lying alongside and parallel to it. If, after the production of a first bore in the earth, a second bore running parallel with the first is required, the guide body 125 having an outer diameter equal to that of the housing of the burrowing apparatus 126 is fixed, for example by screwing, to the housing and is inserted into the existing bore by its tip which projects forward of the striker tip of the burrowing apparatus. After starting up the burrowing apparatus, a second bore of equal diameter is bored parallel with the first bore. Moreover, during formation of the second bore the first bore does not suffer any appreciable alteration due to displacement of the earth from the second bore, because the guide body 125 advances in the first bore in front of the burrowing apparatus in the second bore, and because the second bore is spaced from the first bore.

Finally, for steering the burrowing apparatus, wings 127 or 128 as in Figs. 11 and 12, respectively, may be provided. The wings 127 are arranged diametrically opposite one another on the housing of the burrowing apparatus at appropriate points, either connected rigidly to the housing or pivoted. More than one pair of wings may be provided. The wings steer the burrowing apparatus automatically in a predetermined arc through the ground depending on their inclination to the longitudinal axis of the housing, so that, for example, even roads with a small embankment can be traversed underneath at an adequate depth by the burrowing apparatus without any excavation of the ground for launching the apparatus. The wings 127 have a shape tapering inwards in the working direction of the apparatus. If the wings are pivoted to the housing, the inclination of the wing to the long axis of the housing may be adjusted, and the arc along which the burrowing apparatus moves through the ground may be thereby selected. This adjustment also enables the path of the apparatus to be set, taking into account the characteristics of the ground to be traversed.

The components of the adjustable connection of the wing 127 to the housing comprise a pivot 129 attached to the housing, on which pivot is seated a hub 130 which is attached, for example by welding, to one end of the associated wing 127. At the other end of the wing 127 is attached a stud 131 which projects into one of a number of bores 132 arranged along an arc centred at the pivot 129 of the wing.

Instead of the wings 127 attached to the housing of the burrowing apparatus, or even in addition to the wings 127, a curved stiff protective tube 44 can be employed for steering the apparatus, which, like the housing in Fig. 11, is shown in Fig. 12 as a detail. If necessary, the tube 44 can be provided with wings 128. The wings 128 preferably have the same curvature as the protective tube and are arranged diametrically opposite each other on the protective tube and parallel with the longitudinal axis of the tube. More than one pair of wings, spaced apart along the tube 44, may be provided.

WHAT WE CLAIM IS:—

1. A self-propelled pneumatically-oper-

ated burrowing apparatus for driving or enlarging holes or channels in earth, the apparatus comprising a tubular housing, a percussion piston which is reciprocable in the housing; and a striker tip arranged to slide in an axial direction relative to the housing and to which kinetic energy can be imparted by the percussion piston in a working direction axial of the housing; in which apparatus the striker tip on impact by the percussion piston thrusts the housing forward in the working direction by acting against adjustably pre-stressed resilient means contained in the housing, and in which the travel of the striker tip relative to the housing is limited by front and back stops.

2. Apparatus as claimed in Claim 1, including an intermediate piston arranged in the line of action between the percussion piston and the striker tip and slidable in the direction of motion of the percussion piston.

3. Apparatus as claimed in Claim 2, in which the intermediate piston is resiliently supported in the housing.

4. Apparatus as claimed in any preceding claim, in which the sticker tip is formed as a gouge.

5. Apparatus as claimed in Claim 4, in which the working end of the striker tip has a concave surface.

6. Apparatus as claimed in any preceding claim, in which the striker tip is provided with a displacement member of larger cross-sectional area than the striker tip for determining the cross-sectional area of the hole.

7. Apparatus as claimed in Claim 8, in which the leading edge of the displacement member is spaced back from the working end of the striker tip.

8. Apparatus as claimed in any one of Claims 1 - 5, in which the housing is provided with a displacement member thereabout which is of larger cross-sectional area than the housing, for determining the cross-sectional area of the hole.

9. Apparatus as claimed in Claim 7 or Claim 8, in which the displacement member is seated on the striker tip or on the housing, respectively, such that it is detachable by movement in the working direction.

10. Apparatus as claimed in any preceding claim, in which a control sleeve is mounted in the housing and has an inner bore formed as a compressed air feed; in which the percussion piston is hollow at its rear end and slides with its hollow rear end in an interspace between the control sleeve and the inner surface of the housing making a seal with both the control sleeve and the inner surface of the housing; and in which an air conduction path extends from the hollow rear end of the percussion piston to the front face of the percussion piston, which path is connected during the working stroke of the percussion piston only with an air outlet in the control sleeve and during the return stroke of the percussion piston only with the inner bore of the control sleeve.

11. Apparatus as claimed in Claim 10, in which the control sleeve is mounted slidably in an axial direction in the housing between two limit positions providing different ratios of the time periods during which the path is connected to the air outlet and to the inner bore of the control sleeve, whereby one limit position results in forward movement of the housing and the other limit position in reverse movement of the housing.

12. Apparatus as claimed in any preceding claim, in which the housing includes a tube which has, on its outside surface, profiled grooves running transversely to its longitudinal axis.

13. Apparatus as claimed in any preceding claim, including a protective tube connected to the rear end of the housing.

14. Apparatus as claimed in Claim 13, in which the protective tube is provided with at least one drainage opening through its wall.

15. Apparatus as claimed in Claim 13 or Claim 14, in which the protective tube is formed of synthetic material.

16. Apparatus as claimed in any preceding claim, including a steering wing attached to the housing or to a curved stiff protective tube fixed to the rear end of the housing.

17. Apparatus as claimed in any preceding claim, including a mounting for aligning the housing at the beginning of a boring operation.

18. Apparatus as claimed in Claim 17, in which the mounting includes two clamps which are held by spring-loaded parallel levers in a closed position in contact with the housing, which levers can be moved against the spring loading to open the clamps.

19. Apparatus as claimed in Claim 17 or Claim 18, in which the mounting is provided with means for checking the alignment of the housing relative to a reference direction, the means including a plumb bob and/or a sighting device.

20. Apparatus as claimed in any one of Claims 17, 18 or 19, in which the mounting includes a platform carrying the clamps, and a baseplate for fixing the mounting to the ground, the platform being connected via a universal joint with the baseplate and being lockable in any position of the baseplate.

21. Apparatus as claimed in Claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

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1,392,868 COMPLETE SPECIFICATION
6 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

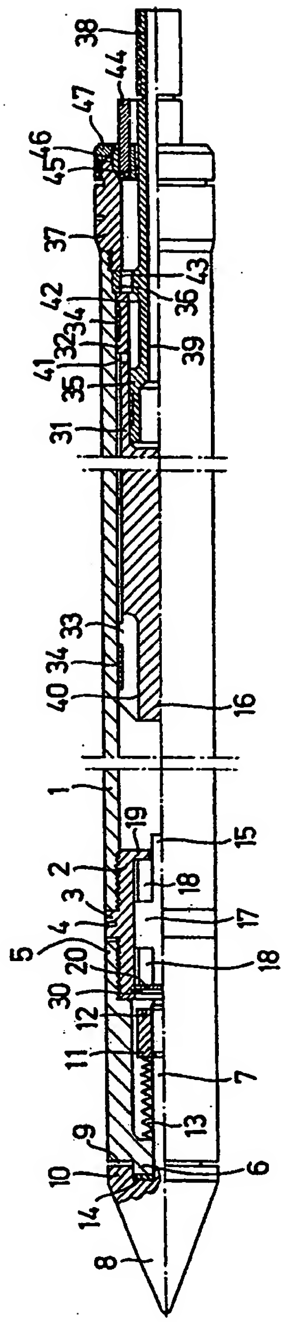

FIG. 1

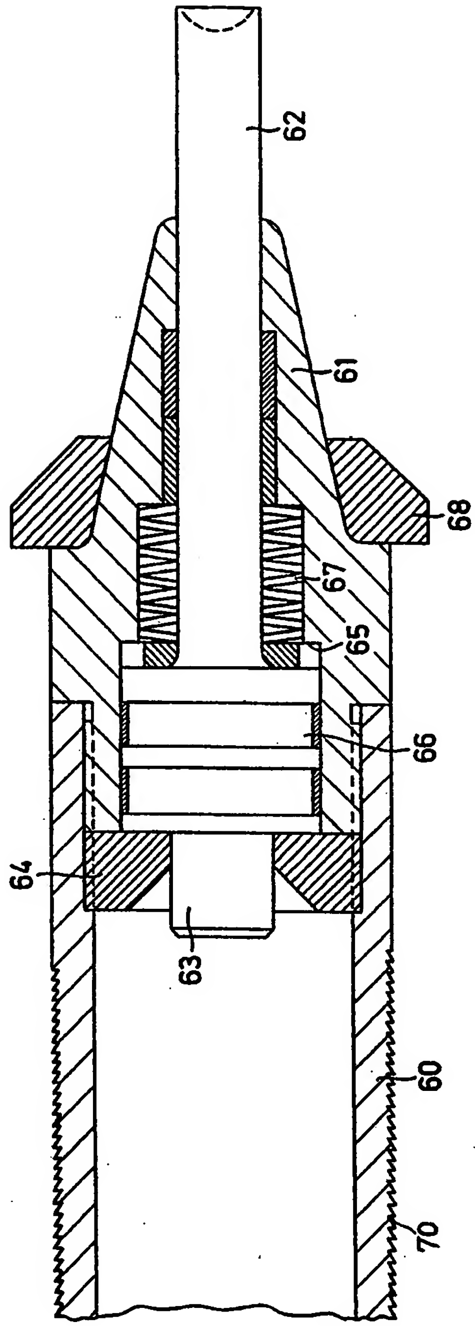

FIG. 2

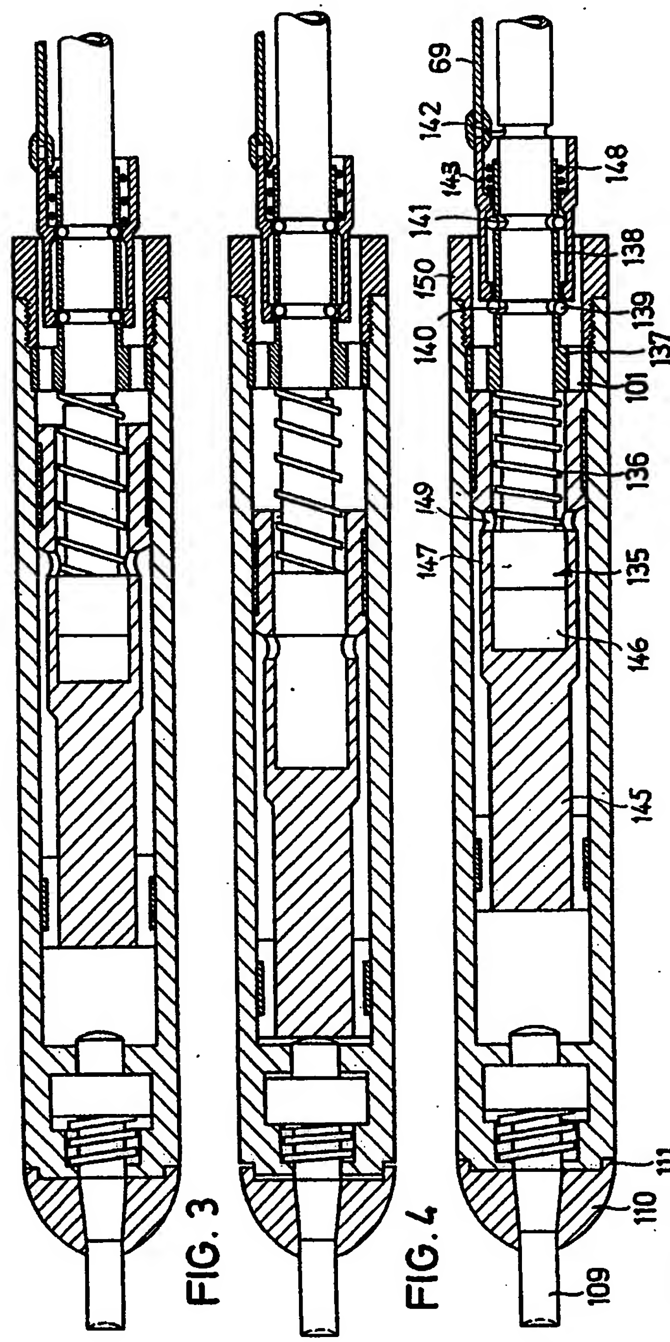

FIG. 3

FIG. 4

FIG. 5

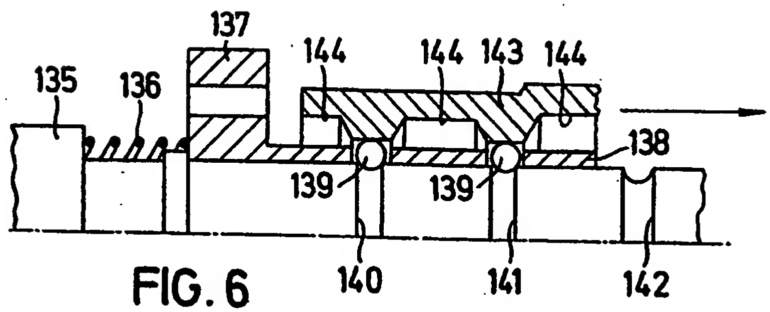

FIG. 6

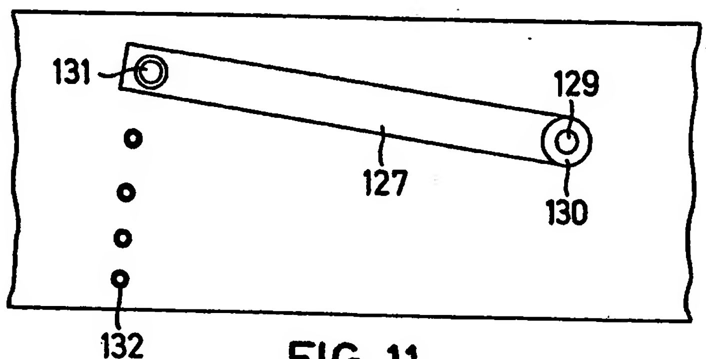

FIG. 11

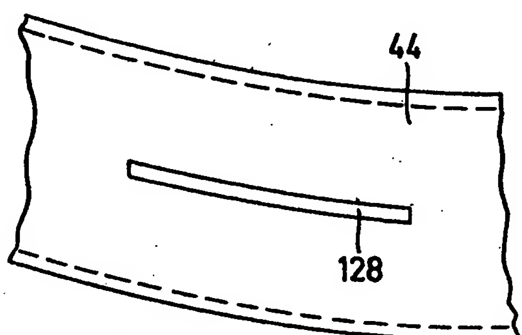

FIG. 12

1,392,868 COMPLETE SPECIFICATION
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SHEET 5

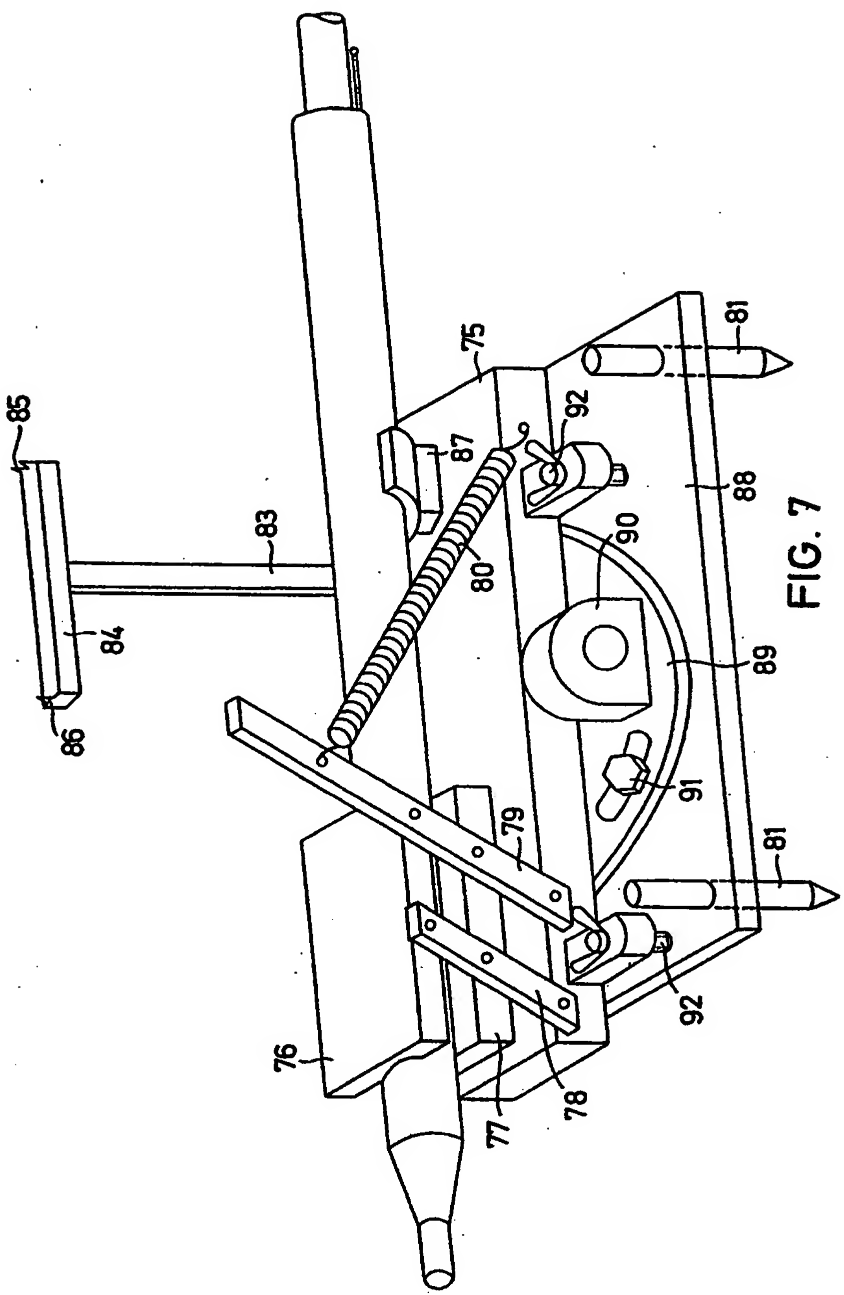

FIG. 7

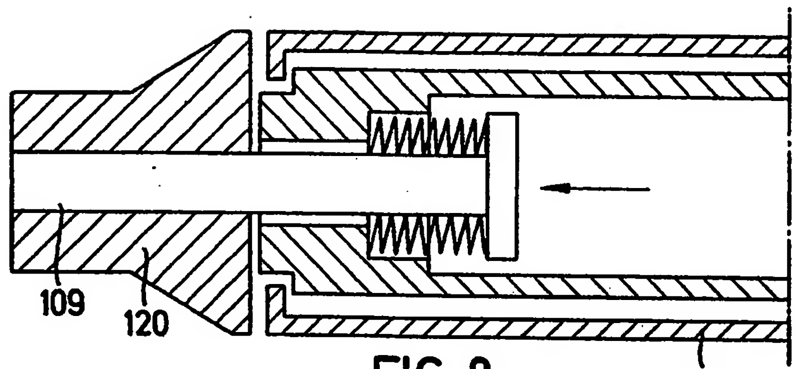

FIG. 8

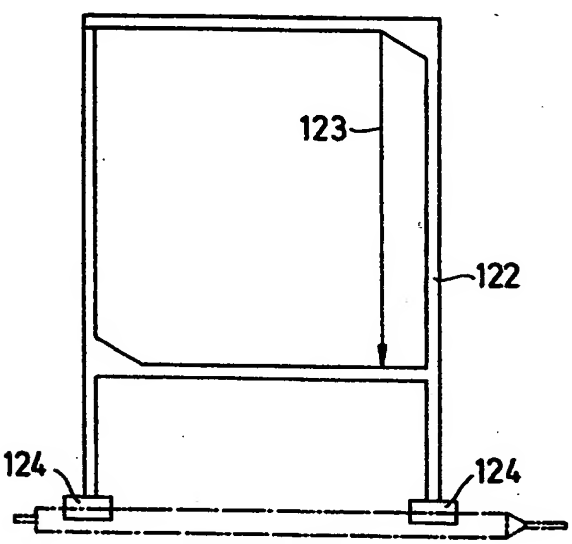

FIG. 9

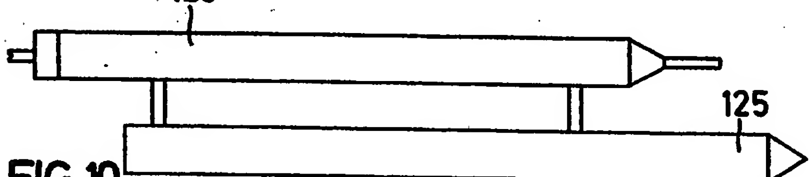

FIG. 10